Title

Open and Closed Reduction for Developmental Dysplasia of the Hip in New York State: Incidence of Hip Reduction and Rates of Subsequent Surgery.

Journal

JB & JS open access, 5(1)

ISSN

2472-7245

Authors

Swarup, Ishaan
Ge, Yile
Scher, David
et al.

Publication Date

2020

DOI

10.2106/jbjs.oa.19.00028

Peer reviewed

JB&JS OPEN ACCESS

Open and Closed Reduction for Developmental Dysplasia of the Hip in New York State

Incidence of Hip Reduction and Rates of Subsequent Surgery

Ishaan Swarup, MD, Yile Ge, MS, David Scher, MD, Ernest Sink, MD, Roger Widmann, MD, and Emily Dodwell, MD, MPH, FRCSC

Investigation performed at the Hospital for Special Surgery, New York, NY

Background: There are limited data on the incidence and outcomes of open and closed hip reduction in patients with developmental dysplasia of the hip (DDH). The aims of this study were to determine the incidence of open and closed reduction of the hip using population-level data and to assess the rates of subsequent surgery.

Methods: Children aged 3 years and younger with DDH who underwent open or closed reduction of the hip between 1997 and 2013 were identified in the New York Statewide Planning and Research Cooperative System (SPARCS) database. Patient age, sex, race, and insurance status as well as concurrent procedures were extracted. Admissions through 2014 were searched for subsequent surgeries, providing a minimum 1-year post-reduction surveillance for all patients. Age-specific incidence rates were calculated using New York State annual population data. The rates of concurrent and subsequent surgeries were calculated. A sensitivity analysis was performed to provide a range for the rates of subsequent surgery. Univariate analyses consisted of chi-square or Fisher exact tests for categorical variables.

Results: In total, 897 patients (637 who underwent closed reduction and 260 who underwent open reduction) were identified. The age-specific incidence per 100,000 population was 12.5 for closed reduction and 2.6 for open reduction for <1-year-olds, 2.2 for both closed and open reductions for 1-year-olds, 0.4 for closed reduction and 1.0 for open reduction for 2-year-olds, and <0.3 for closed reduction and 0.5 for open reduction for 3-year-olds. Overall, closed reductions were performed more frequently over the study period ($p < 0.01$). The estimated rate of subsequent ipsilateral surgery was 12.4% (range, 9.4% to 33.1%) after index closed reduction and was 14.2% (range, 8.5% to 40.1%) after index open reduction.

Conclusions: We found that the incidence of closed or open hip reduction for DDH was small and that there was an increase in the number of closed reductions performed over time. The rates of subsequent surgery remained relatively high for patients after index closed or open hip reduction.

Level of Evidence: Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

Developmental dysplasia of the hip (DDH) encompasses a spectrum of abnormal hip development in utero or in the perinatal period[1]. DDH can range from mild dysplasia of the acetabulum to irreducible dislocation of the hip, and its clinical features depend on several factors, including the age of the child, the severity of the abnormality, and whether there is unilateral or bilateral involvement[2]. When DDH is detected at an early age, the treatment is often more successful, with improved long-term outcomes[3]. In the first 6 months of life, DDH is most commonly treated with use of a brace or harness, with successful treatment in 70% to 95% of cases[1,4,5]. In older children, the Pavlik harness has a lower success rate, and it has been associated with a higher risk of osteonecrosis of the femoral head[6]. As a result, patients in whom treatment with a brace fails or who present at ≥6 months of age are often treated with closed or open reduction of the hip under general anesthesia[2,7,8]. Closed reduction of the hip is usually performed in younger children. Open reduction of the hip is traditionally reserved for patients in whom closed reduction has failed, who present late, or who have a fixed or teratologic dislocation[2,7,9].

Disclosure: The authors indicated that no external funding was received for any aspect of this work. The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJSOA/A141).

The rates of closed and open hip reductions in the infant and toddler years have not been clearly identified, nor has the rate of subsequent surgery after hip reduction. The primary aim of the current study was to determine the incidence of open and closed reductions of the hip. The secondary aim of this study was to determine the rates of subsequent surgery after index closed and open reductions of the hip.

Materials and Methods

Infants and young children from birth to age 3 years (inclusive) who underwent closed or open reduction of the hip for DDH between 1997 and 2013 were identified in the New York Statewide Planning and Research Cooperative System (SPARCS) database. SPARCS contains a census of all hospital admissions and cases of ambulatory surgery performed in New York State, with the exception of cases performed in federal hospitals (e.g., Veterans Affairs or other military hospitals, or penitentiaries). This data set includes surgeries performed by every surgeon and on every patient in New York State, provided they were performed in nonfederal hospitals. Admissions through 2014 were searched to identify subsequent surgeries, providing a minimum 1-year post-reduction surveillance for each patient. The median surveillance duration was 110 months (range, 12 to 215 months). Patients residing outside of New York State were excluded, as it was hypothesized that these patients may be more likely to have follow-up in their home state, and thus subsequent surgeries for these patients were less likely to be captured in this longitudinal database. Similar methodology using the SPARCS database has been used in other studies[10].

Cases of closed or open reduction were identified by International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) procedure codes for inpatient procedures and Current Procedural Terminology, Fourth Edition (CPT-4) procedure codes for ambulatory surgery procedures. Only patients with a concurrent diagnosis code for DDH were included, while patients also having a neurologic or spinal cord or syndromic diagnosis code were excluded. Patients who had a hip procedure prior to the index (i.e., first) reduction were also excluded. ICD-9-CM procedure codes and CPT-4 procedure codes were also used to identify concurrent hip procedures as well as subsequent hip surgery after the index reduction. The concurrent and subsequent procedures of interest included subsequent closed hip reduction, subsequent open hip reduction, pelvic osteotomy, femoral osteotomy, and other hip procedures. Appendix A lists all ICD-9-CM and CPT-4 codes used to classify diagnoses and procedures of interest for this study.

Inpatient procedures were classified as bilateral when the procedure was recorded for a given patient more than once on the same day; otherwise, the procedure was considered unilateral. Ambulatory surgery procedures were classified as bilateral, right or left, according to the recorded CPT modifier when present, and unilateral otherwise. Because of the high number of cases for which the index reduction or subsequent surgery was classified as unilateral (i.e., laterality was not recorded for at least 1 procedure), estimates of subsequent ipsilateral procedures were calculated using 3 scenarios: (1) subsequent procedures performed ≤21 days of the index hip reduction were classified as ipsilateral, and procedures performed >21 days after the initial reduction were classified as contralateral procedures, (2) any subsequent procedure was considered to be contralateral to the index hip reduction, and (3) any subsequent procedure was considered to be ipsilateral to the index hip reduction (Fig. 1). For analyses of subsequent procedures, we report Scenario 1 because it most accurately reflects clinical practice, and we include Scenarios 2 and 3 as ranges representing the best and worst-case scenarios, respectively.

Patient characteristics from SPARCS included in the analytic data sets were month and year of birth, sex, race (white,

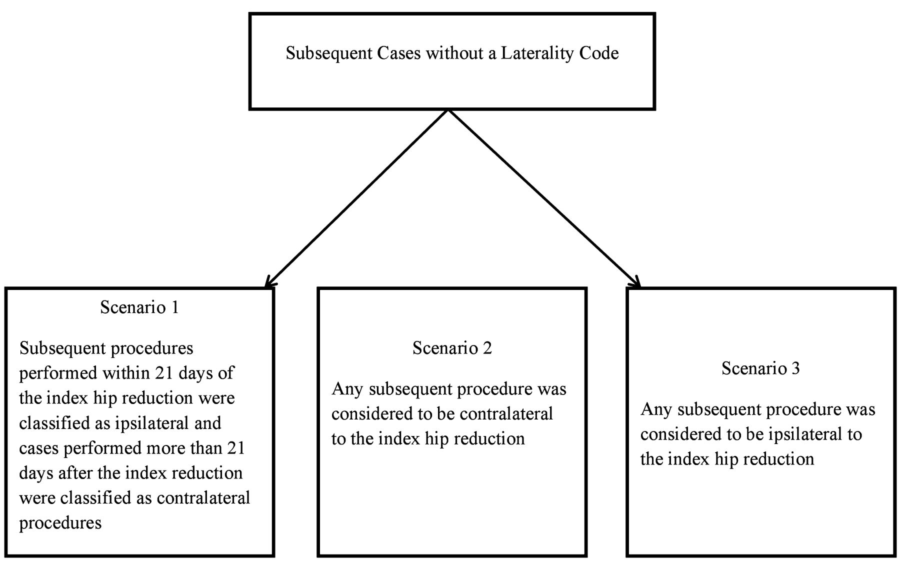

Fig. 1

Classification of subsequent ipsilateral cases without a laterality code.

black, other, unknown), and insurance status (Medicaid versus all other payers). The incidence per 100,000 population by year of age (<1, 1, 2, and 3) for open and closed reductions was calculated using annual population estimates from 1997 to 2013, obtained from the New York State Department of Health Vital Statistics[11]. Age in months at the time of the index reduction was calculated by subtracting the month and year of birth from the month and year of the reduction admission. Patient ZIP code-level poverty prevalence was obtained from the 2000 Census data and dichotomized as >20% or ≤20%, which represents the 75th percentile of poverty prevalence in the study population.

Statistical Analysis

Univariate analyses consisted of chi-square or Fisher exact tests for categorical variables. The rates of subsequent closed reduction, open reduction, pelvic osteotomy, femoral osteotomy, and other hip procedures are presented for each type of reduction based on Scenario 1 (ipsilateral if ≤21 days and contralateral if >21 days), with the range representing Scenarios 2 (all contralateral) and 3 (all ipsilateral). Kendall tau-b correlation coefficients were calculated to examine trends over time. Statistical analysis was performed using SAS software (version 9.4; SAS Institute), with the significance level set at 0.05.

Results

Incidence of Closed and Open Hip Reduction

From 1997 to 2013, there were 897 patients aged 0 to 3 years (inclusive) who underwent closed reduction (637 patients) or open reduction (260 patients) (Table I). The age-specific incidence per 100,000 population was 12.5 for closed reduction and 2.6 for open reduction for <1-year-olds, 2.2 for closed reduction and 2.2 for open reduction for 1-year-olds, 0.4 for closed reduction and 1.0 for open reduction for 2-year-olds, and <0.3 for closed reduction and 0.5 for open reduction for 3-year-olds. The incidence of closed reduction appeared to increase slightly over time (Kendall tau-b, 0.32; p = 0.070), while the incidence of open reduction was stable (Kendall tau-b, –0.10; p = 0.564) (Fig. 2). Overall, closed reductions were performed more frequently over the study period (p < 0.01). The median age at the index closed reduction was 6 months (range, 0 to 47 months), while the median age at open reduction was 16 months (range, 1 to 48 months).

Subsequent Surgery After Index Hip Reduction

The rate of any subsequent ipsilateral surgery after the index closed reduction was 12.4% (range, 9.4% to 33.1%), and the rate of any subsequent ipsilateral surgery after the index open

TABLE I Demographics and Surgical Details for Open and Closed Hip Reduction Among Children with DDH ≤3 Years of Age in New York State

	Closed Reduction		Open Reduction		
	No. of Patients	%*	No. of Patients	%*	P Value
Total	637	71.0	260	29.0	
Age in yr					<0.001
0	523	82.1	107	41.2	
1	91	14.3	92	35.4	
2	†	†	40	15.4	
3	†	†	21	8.1	
Sex					0.001
Female	532	83.5	193	74.2	
Male	105	16.5	67	25.8	
Race					0.035
White	386	60.6	149	57.3	
Black	27	4.2	24	9.2	
Other	183	28.7	72	27.7	
Unknown	41	6.4	15	5.8	
Insurance					0.205
Medicaid	267	41.9	121	46.5	
All others	370	58.1	139	53.5	
Poverty rate					
ZIP code poverty prevalence >20%	152	23.9	84	32.3	0.033
Concurrent procedures					
Femoral osteotomy	†	†	71	27.3	<0.001
Pelvic osteotomy	†	†	45	17.3	<0.001

*The percentages shown for the "Total" row are of the total number of patients (n = 897). All other percentages are of the given group (n = 637 for closed and n = 260 for open reduction). †Results and derivatives where cell counts are <11 have been redacted to comply with SPARCS small-cell-size policies.

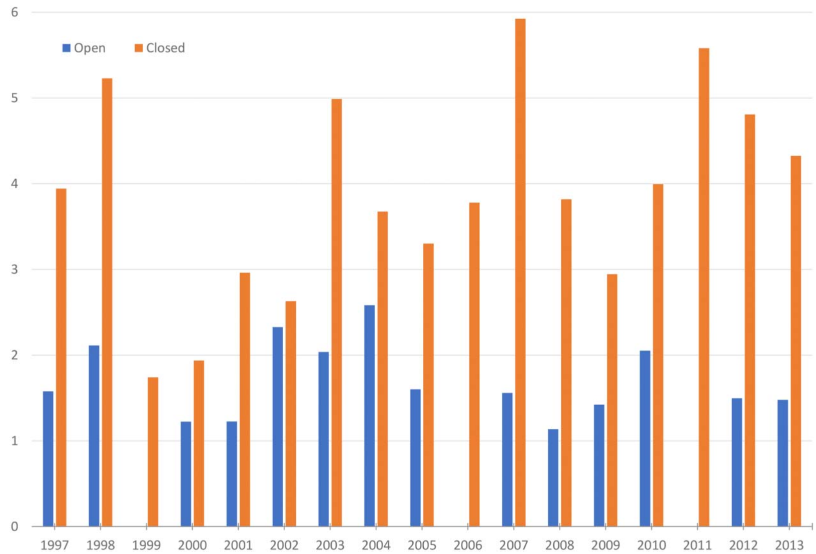

Fig. 2
Incidence of open and closed reduction per 100,000 in the New York State population of children ≤3 years of age with developmental dysplasia of the hip.

reduction was 14.2% (range, 8.5% to 40.1%). Patient characteristics are summarized by subsequent surgery status in Table II.

Among patients who underwent an index closed reduction, the rate of subsequent repeat closed reduction was 8.8% (range, 7.4% to 20.3%), and the rate of subsequent open reduction was 4.7% (range, 2.7% to 12.1%). The rate of subsequent femoral osteotomy among these patients was 2.0% (range, <1.7% to 6.8%), and the rate of subsequent pelvic osteotomy was <1.7% (range, <1.7% to 8.0%). For patients who underwent an index open reduction, the rate of repeat open reduction was 5.4% (range, <4.2% to 19.6%). The rate of subsequent femoral osteotomy after an index open reduction was 5.8% (range, 5.0% to 20.4%), and the rate of subsequent pelvic osteotomy was <4.2% (range, <4.2% to 11.9%). The estimated rates of ipsilateral procedures for all surgery categories and scenarios by type of index reduction are presented in Tables III and IV.

TABLE II Characteristics of Patients with or without Any Subsequent Hip Procedure

	Subsequent Procedure			
	Yes		No	
	No.	%*	No.	%*
Index reduction type				
Closed	214	66.9	423	73.3
Open	106	33.1	154	26.7
Age in yr				
0	206	64.4	424	73.5
1	76	23.8	107	18.5
2	25	7.8	33	5.7
3	13	4.1	13	2.3
Sex				
Female	248	77.5	477	82.7
Male	72	22.5	100	17.3
Race				
White	179	55.9	356	61.7
Black	15	4.7	36	6.2
Other	109	34.1	146	25.3
Unknown	17	5.3	39	6.8
Insurance				
Medicaid	157	49.1	231	40.0
All others	163	50.9	346	60.0
Poverty rate				
ZIP code poverty prevalence >20%	87	27.2	149	25.8

*The percentages are of the total number of patients with (n = 320) or without (n = 577) any subsequent procedure.

Discussion

The aims of this study were to determine the population-level incidence of open and closed reduction of the hip in infants and young children with DDH, and to assess the rates of subsequent ipsilateral surgery after the index hip reduction. The incidence of closed hip reduction in the first year of life was 12.5 per 100,000, and for open reduction, it was 2.6 per 100,000. Incidence decreased over the subsequent years; at the age of 3, there was <1 reduction procedure per 100,000 for both closed and open reductions. The median patient age for closed reduction was 6 months, and the median age for open reduction was 16 months. Annual trends showed that the type of reduction changed over the 17-year study period, with more closed than open reductions being performed over time. This trend was due to an increase in closed reductions, as the rates of open reductions remained relatively constant. The reasons for the increase in closed reductions are

TABLE III Rate of Subsequent Ipsilateral Procedures in Patients Having Index Closed Reduction (N = 637)

	Scenario*					
	1		2		3	
Subsequent Procedure	No.	%	No.	%	No.	%
Any ipsilateral procedure	79	12.4	60	9.4	211	33.1
Open reduction	30	4.7	17	2.7	77	12.1
Closed reduction	56	8.8	47	7.4	129	20.3
Femoral osteotomy	13	2.0	†	†	43	6.8
Pelvic osteotomy	†	†	†	†	51	8.0

*Scenario 1 = procedures without known laterality classified as ipsilateral if ≤21 days of the index reduction and contralateral if >21 days. Scenario 2 = all unknown laterality procedures classified as contralateral. Scenario 3 = all unknown laterality procedures classified as ipsilateral. †Results and derivatives where cell counts are <11 have been redacted to comply with SPARCS small-cell-size policies.

unclear, but may be secondary to increased awareness and earlier diagnosis of DDH, or the implementation of screening programs[12].

There is a paucity of literature on the epidemiology of open and closed reduction for DDH. A recent study by Nelson et al. using the Healthcare Cost and Utilization Project Kids' Inpatient Database (KID) found a decrease in the frequency of closed reduction compared with open reduction over time, and reported a mean age of 0.8 year at the time of closed reduction and a mean age of 2.8 years at the time of open reduction[13]. We found a different trend in our population, with an increase in the frequency of closed reductions over time and younger median age at the time of open and closed reductions. These differences may be due to the fact that Nelson et al. averaged national data[13], whereas we focused on trends and practice in New York State. Chang et al. reported an average age of 1.7 years at the time of reduction in a Taiwanese population; however, the authors did not distinguish between types of reduction[14]. In general, this is the first study to our knowledge to show state-level data regarding the incidence of hip reductions in the infant and toddler years. Assuming that all children identified with a hip dislocation undergo reduction in a timely manner, these data can be used as a proxy for the need for index reduction for DDH, with a total incidence of 5.4 per 100,000 in the first 4 years of life.

Up to one-third of the patients who underwent an index closed reduction underwent a subsequent ipsilateral surgery, and up to 12% of the patients initially treated with a closed reduction underwent a subsequent open reduction. In comparison, up to 40% of the patients who underwent an index open reduction needed a subsequent ipsilateral surgery. The most common procedures following open or closed hip reduction are pelvic and femoral osteotomies. Previous studies have found reoperation rates ranging from 25% to 74% after index open and closed reduction, but they have been limited to smaller sample sizes and single institutions[8,15-17]. The lack of documented laterality is a notable limitation of database studies, and in the current study, we performed a sensitivity analysis of the best and worst-case scenarios. We report a range of rates to provide a more accurate assessment of the rate of subsequent ipsilateral surgery. The ranges are relatively narrow and provide orthopaedic surgeons with additional data for patient counseling and surgical decision-making.

This study had several limitations. First, this was a retrospective population study based on data from New York State. Treatment practices for DDH vary widely by geography and even by surgeon practice. The results of this study may not be generalizable to national or international practices and trends. Second, this database does not include follow-up data for patients who received care outside of New York after the initial reduction. While patients with out-of-state addresses at the time of the index hip reduction were excluded (as it was hypothesized that non-New York residents may be more likely to seek follow-up care outside of the state), subsequent procedures received by patients who were included in our analysis but who moved out of state after the index reduction may not have been captured. Because of these factors, it is possible that our analysis underestimates the rate of subsequent surgery. Some patients may have also required additional procedures but did not receive additional treatment, which may further underestimate the rate of subsequent surgery. It is important to recognize that receiving surgery does not imply that surgery was required. Lastly, we used an administrative database, which limits our ability to analyze clinical and radiographic outcomes as well as clearly identify risk factors for subsequent surgery. However, we have used a consistent methodology supported by clinical practice in order to minimize the risk of misclassification, and we performed a sensitivity analysis using multiple scenarios to provide an accurate assessment of the rates of subsequent surgery.

The results of this study have important implications for clinical practice. Most notably, this study provides public health officials with an accurate assessment of the incidence of open and closed reduction, and it provides orthopaedic surgeons and patients with a population-based assessment of subsequent procedures after index hip reduction. Specifically, surgeons may wish to advise parents and caregivers that up to one-third of patients may require a subsequent ipsilateral hip procedure after an index closed reduction, and up to 40% of patients may require a subsequent procedure

TABLE IV Rate of Subsequent Ipsilateral Procedures in Patients Having Index Open Reduction (N = 260)

	Scenario*					
	1		2		3	
Subsequent Procedure	No.	%	No.	%	No.	%
Any procedure	37	14.2	22	8.5	106	40.8
Open reduction	14	5.4	†	†	51	19.6
Femoral osteotomy	15	5.8	13	5.0	53	20.4
Pelvic osteotomy	†	†	†	†	31	11.9

*Scenario 1 = procedures without known laterality classified as ipsilateral if ≤21 days of index reduction and contralateral if >21 days. Scenario 2 = all unknown laterality procedures classified as contralateral. Scenario 3 = all unknown laterality procedures classified as ipsilateral. †Results and derivatives where cell counts are <11 have been redacted to comply with SPARCS small-cell-size policies.

after an index open reduction. These data help to set expectations that are aligned with actual clinical outcomes. While the results of this study are illuminating, data from large prospective registries are necessary to confirm the findings of this study and to determine the burden of disease for DDH in other populations.

Appendix

eA Supporting material provided by the authors is posted with the online version of this article as a data supplement at jbjs.org (http://links.lww.com/JBJSOA/A142). ■

Ishaan Swarup, MD[1]
Yile Ge, MS[2]
David Scher, MD[2]
Ernest Sink, MD[2]
Roger Widmann, MD[2]
Emily Dodwell, MD, MPH, FRCSC[2]

[1]UCSF Benioff Children's Hospital, Oakland, California

[2]Hospital for Special Surgery, New York, NY

Email address for E. Dodwell: dodwelle@hss.edu

ORCID iD for I. Swarup: 0000-0003-3481-3408
ORCID iD for Y. Ge: 0000-0001-9521-4578
ORCID iD for D. Scher: 0000-0002-2715-7919
ORCID iD for E. Sink: 0000-0001-8221-8350
ORCID iD for R. Widmann: 0000-0003-0612-4429
ORCID iD for E. Dodwell: 0000-0001-8424-4341

References

1. Swarup I, Penny CL, Dodwell ER. Developmental dysplasia of the hip: an update on diagnosis and management from birth to 6 months. Curr Opin Pediatr. 2018 Feb;30(1):84-92.

2. Vitale MG, Skaggs DL. Developmental dysplasia of the hip from six months to four years of age. J Am Acad Orthop Surg. 2001 Nov-Dec;9(6):401-11.

3. American Academy of Pediatrics. Clinical practice guideline: early detection of developmental dysplasia of the hip. Committee on Quality Improvement, Subcommittee on Developmental Dysplasia of the Hip. Pediatrics. 2000 Apr;105(4 Pt 1):896-905.

4. Novais EN, Hill MK, Carry PM, Heyn PC. Is age or surgical approach associated with osteonecrosis in patients with developmental dysplasia of the hip? A meta-analysis. Clin Orthop Relat Res. 2016 May;474(5):1166-77.

5. Upasani VV, Bomar JD, Matheney TH, Sankar WN, Mulpuri K, Price CT, Moseley CF, Kelley SP, Narayanan U, Clarke NM, Wedge JH, Castañeda P, Kasser JR, Foster BK, Herrera-Soto JA, Cundy PJ, Williams N, Mubarak SJ. Evaluation of brace treatment for infant hip dislocation in a prospective cohort: defining the success rate and variables associated with failure. J Bone Joint Surg Am. 2016 Jul 20;98(14):1215-21.

6. Pollet V, Pruijs H, Sakkers R, Castelein R. Results of Pavlik harness treatment in children with dislocated hips between the age of six and twenty-four months. J Pediatr Orthop. 2010 Jul-Aug;30(5):437-42.

7. Gruel CR, Birch JG, Roach JW, Herring JA. Teratologic dislocation of the hip. J Pediatr Orthop. 1986 Nov-Dec;6(6):693-702.

8. Murray T, Cooperman DR, Thompson GH, Ballock RT. Closed reduction for treatment of developmental dysplasia of the hip in children. Am J Orthop (Belle Mead NJ). 2007 Feb;36(2):82-4.

9. Weinstein SL, Mubarak SJ, Wenger DR. Developmental hip dysplasia and dislocation: part II. Instr Course Lect. 2004;53:531-42.

10. Dodwell E, Wright J, Widmann R, Edobor-Osula F, Pan TJ, Lyman S. Socioeconomic factors are associated with trends in treatment of pediatric femoral shaft fractures, and subsequent implant removal in New York State. J Pediatr Orthop. 2016 Jul-Aug;36(5):459-64.

11. United States Census Bureau. 2015 state population estimates by age, sex, race and Hispanic origin. https://www.census.gov/newsroom/press-kits/2018/estimates-characteristics.html. Accessed 2019 Nov 13.

12. Shorter D, Hong T, Osborn DA. Screening programmes for developmental dysplasia of the hip in newborn infants. Cochrane Database Syst Rev. 2011 Sep 7;9:CD004595.

13. Nelson SE, DeFrancesco CJ, Sankar WN. Operative reduction for developmental dysplasia of the hip: epidemiology over 16 years. J Pediatr Orthop. 2019 Apr;39(4):e272-7.

14. Chang CH, Chiang YT, Lee ZL, Kuo KN. Incidence of surgery in developmental dysplasia of the hip in Taiwan. J Formos Med Assoc. 2007 Jun;106(6):462-6.

15. Schoenecker PL, Dollard PA, Sheridan JJ, Strecker WB. Closed reduction of developmental dislocation of the hip in children older than 18 months. J Pediatr Orthop. 1995 Nov-Dec;15(6):763-7.

16. Zionts LE, MacEwen GD. Treatment of congenital dislocation of the hip in children between the ages of one and three years. J Bone Joint Surg Am. 1986 Jul;68(6):829-46.

17. Gholve PA, Flynn JM, Garner MR, Millis MB, Kim YJ. Predictors for secondary procedures in walking DDH. J Pediatr Orthop. 2012 Apr-May;32(3):282-9.